STUDY GUIDE

DISINFECTION

INTRODUCTION AND ADVANCED

SUBCLASS E

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JANUARY 1994 EDITION

This operator's study guide represents the results of an ambitious program. Operators of wastewater facilities, regulators, educators and local officials, jointly prepared the objectives and exam questions for this subgrade.

The objectives in this study guide have been organized into modules, and within each module they are grouped by major concepts.

HOW TO USE THESE OBJECTIVES WITH REFERENCES

In preparation for the exams, you should:

1. Read all the objectives that apply to the grade level desired and write down the answers to the objectives that readily come to mind.

2. Use the references at the end of the study guide to look-up answers you don't know. This one set of references covers all of the objectives.

3. Write down the answers found in the references to those objectives you could not answer from memory.

4. Review all answered objectives until you can answer each from memory.

IT IS ADVISABLE THAT YOU ATTEND SOME FORM OF FORMAL TRAINING IN THIS PROCESS BEFORE ATTEMPTING THE CERTIFICATION EXAM.

Choosing A Test Date

Before you choose a test date, consider the training opportunities available in your area. A listing of training opportunities and exam dates can be found in the annual DNR "Certified Operator," or by contacting your DNR District operator certification coordinator.

INTRODUCTION

INTRODUCTION TO DISINFECTION

MODULE A: PRINCIPLE, STRUCTURE AND FUNCTION

CONCEPT: PRINCIPLE OF DISINFECTION

1. Define pathogenic organisms and their source in wastewater.

2. Name the type of organism (bacteria, virus, or parasite) responsible for causing the following waterborne diseases:

   A. Typhoid Fever
   B. Dysentery
   C. Cholera
   D. Salamonellosis
   E. Hepatitis A
   F. Giardiasis
   G. Amoebic Dysentery

3. State the reasons for disinfecting wastewater, including seasonal disinfection.

4. List the most common methods of disinfecting treated wastewater.

5. Explain the relationship between chlorine dosage, chlorine demand, and chlorine residual.

6. Describe conditions that affect chlorine demand.

7. Define dechlorination, the chemicals commonly used, and why it is done at wastewater treatment plants.

8. Define hypochlorination and the chemicals commonly used in this process.

9. Describe ultraviolet disinfection and the main advantage of its use.

CONCEPT: STRUCTURE AND FUNCTION

10. Describe the location where chlorine should be added for wastewater disinfection.

11. Describe a typical chlorine contact tank and its purpose.

12. Discuss how a typical ultraviolet disinfection unit functions.

13. Explain the following for chlorine and sulfur dioxide 150 pound cylinders and 1 ton tanks:

    A. The Weight of a Full Cylinder or Tank
    B. How the Cylinder or Tank is Handled
    C. How the Cylinder or Tank is Stored
    D. The Form of Chemical (Gas or Liquid)

14. Explain how chlorine can be withdrawn as a liquid or gas from a cylinder or tank.

15. Identify the parts of valves used on 150 pound cylinders and 1 ton tanks.

16. Discuss the purpose of a fusible plug, and where it is located on 150 pound cylinders and 1 ton tanks.

17. Describe a yoke adapter connection used on chlorine cylinder valves.

18. Discuss the following requirements for the storage of chlorine.

    A. Type of Room and Location
    B. Door Opening and Location
    C. Window for the Storage Room
    D. Temperature for the Storage Room
    E. Ventilation for the Storage Room
    F. Chlorinator Location(150 Pound Cylinders and 1 Ton Tanks)
    G. Measuring Chlorine Usage

19. Explain the purpose of the following parts of a vacuum operated solution feed chlorinator.

    A. Vacuum Regulating Valve
    B. Gas Flow Rate Valve (V-Notch Variable Orifice)
    C. Rotameter
    D. Injector.

20. Describe the equipment (sulfonators and cylinders) used for dechlorination with Sulfur Dioxide.

21. Describe the following parts of a hypochlorination system.

    A. Positive Displacement Metering Pump
    B. Solution/Storage Tank

MODULE B: OPERATION AND MAINTENANCE

CONCEPT: OPERATION

22. Describe the procedure for opening the valve on chlorine cylinders.

23. List the steps to start-up a gas chlorination system.

24. Describe what is used to adjust the chlorine gas flow rate, how the flow rate is measured, and how the total daily usage is determined.

25. List the steps for removing an empty 150 pound chlorine cylinder.

26. List the steps for shut-down of a gas chlorination system when seasonal disinfection is required.

27. Describe how to get good mixing of the chlorine solution with the plant effluent.

28. Discuss operational storage concerns when using the following:

    A. Sodium Hypochlorite
    B. Calcium Hypochlorite

29. Discuss the feeding of sulfur dioxide for dechlorination, and the relation to chlorine residual.

30. Describe the effluent characteristics that can inhibit the effectiveness of ultraviolet disinfection.

CONCEPT: MAINTENANCE

31. Discuss the term "Preventive Maintenance."

32. List the maintenance concerns for gas chlorinator and sulfonator systems.

33. List the maintenance concerns for hypochlorination systems.

34. Explain why a chlorine contact tank should be cleaned.

35. List the maintenance concerns for ultraviolet (UV) disinfection systems.

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MODULE C: MONITORING AND TROUBLESHOOTING

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CONCEPT: MONITORING

36. Define the organism used to determine the effectiveness of disinfection.

37. Explain the significance of the use of an indicator organism.

38. Discuss the discharge permit limits for fecal coliform.

39. Describe where samples should be taken to measure the effectiveness of disinfection.

40. Explain the type of fecal coliform sample to be taken, what the sample holding time would be, and sample preservation requirements.

41. Explain the type of chlorine residual sample to be taken, where to collect the sample, and the recommended holding time.

42. State the acute toxic value for total chlorine residual.

43. List the three recommended testing methods for total chlorine residual.

44. Discuss the management concerns for chlorination and dechlorination, and the problem with detection limits when testing for total chlorine residual.

CONCEPT: TROUBLESHOOTING

45. Given the following problems with a gas chlorination system, state the cause and solution for each:

    A. No Gas Flow
    B. Low Gas Pressure
    C. Frosting of the Cylinder
    D. Loss of Vacuum

46. Discuss the causes and solutions for wide variations in chlorine residuals in the final effluent caused by:

    A. Upstream Treatment Units
    B. Chlorine Contact Tank
    C. Chlorine Solution Diffuser

47. List the possible causes of fecal coliform levels that exceed the discharge permit levels for both chlorination systems and ultraviolet units.

48. List the causes of high chlorine residuals following dechlorination.

49. Explain what effect chlorine or sulfur dioxide gas has when released into a moist atmosphere.

50. Discuss the significance of discoloration or corrosion of gas piping systems.

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MODULE D: SAFETY AND CALCULATION

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CONCEPT: SAFETY

51. Discuss the safety concerns of the following:

    A. Chlorine
    B. Sulfur Dioxide

52. List the items that should be included in safety programs for chlorine and sulfur dioxide usage.

53. Describe how to locate small leaks of chlorine or sulfur dioxide.

54. Explain the importance of having a stand-by person available when working with chlorine or sulfur dioxide systems.

55. Explain the safety concerns for the following cylinder equipment:

    A. Packing Retainer Nut
    B. Cylinder Valves
    C. Gaskets
    D. Cylinder Protective Hood
    E. Fusible Plug

56. Describe the type of respiratory protection that should be provided when working with chlorine or sulfur dioxide leaks.

57. Explain why a release of liquid chlorine is much worse than a gas leak.

58. Discuss what items should not be in a chlorine storage room.

59. Describe the safety concerns when using ultraviolet disinfection systems.

CONCEPT: CALCULATION

60. Given data, calculate the applied chlorine dosage in mg/L.

61. Given data, calculate chlorine feed rate per day.

62. Given data, calculate chlorine demand of an effluent.

63. Given data calculate the amount of chlorine used per day.

64. Given data, calculate the amount of hypochlorite solution to feed per day.

ADVANCED

MODULE A: PRINCIPLE, STRUCTURE AND FUNCTION

CONCEPT: PRINCIPLE OF DISINFECTION

1. Explain the difference between disinfection and sterilization.
2. List the methods of disinfection, and identify the three most common.
3. Discuss the reactions of free chlorine and hypochlorites when mixed with water.
4. Discuss the reaction of chlorine and ammonia.
5. List the physical properties of Chlorine (Liquid and Gas) for the following:

   A. Boiling Point (At Atmospheric Pressure)
   B. Density
   C. Specific Gravity
   D. Color
   E. Odor
   F. Solubility In Water

6. Discuss the significance of chlorinated compounds formed during the disinfection of wastewater.
7. Discuss how radiation wavelengths are measured, and compare the ultraviolet wavelength with visible light wavelength.
8. Describe how ultraviolet radiation is generated.

CONCEPT: STRUCTURE AND FUNCTION

9. Discuss the plant location of chlorination equipment (cylinders and tanks) based on the size of the chlorine container.
10. Discuss the purpose of chlorine evaporators.
11. Describe the materials used for the following in handling chlorine gas and liquid:

12. Describe the difference in equipment (including valves) used for Sulfur Dioxide as compared to Chlorine.

13. List the advantages and disadvantages of using gas chlorination, hypochlorination, and ultraviolet radiation for wastewater disinfection.

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MODULE B: OPERATION AND MAINTENANCE

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CONCEPT: OPERATION

14. Define the following terms:

    A. Free Available Chlorine
    B. Combined Available Chlorine
    C. Total Chlorine Residual

15. Discuss the affect on chlorination of the following:

    A. Contact Time
    B. Temperature
    C. pH
    D. Suspended Solids
    E. Organic and Inorganic Materials

16. Discuss mixing and storage requirements when using sodium and calcium hypochlorite.

17. Discuss the desirable temperature range for chlorine and sulfur dioxide gas systems.

18. List the maximum withdrawal rates from 150 pound cylinders and 1 ton tanks for chlorine and sulfur dioxide gas at room temperature (70^{o}F.), and what alternatives can be used if higher rates are required.

19. Describe how gas flow rates are adjusted and measured.

20. Describe the following methods used to control chlorine and sulfur dioxide dosages:

    A. Manual Control
    B. Start-Stop Control
    C. Step-Rate Control
    D. Time-Program Control
    E. Flow-Proportional Control
    F. Chlorine Residual Control

21. Discuss the chemical reactions, the feed rates, and the required contact times of the following common dechlorination compounds used in removing chlorine:

    A. Sulfur Dioxide (SO_2)
    B. Sodium Metabisulfite ($Na_2S_2O_5$)
    C. Sodium Bisulfite ($NaHSO_3$)

22. Discuss the factors that affect hypochlorination chlorine dosages.

23. Describe the consequences of over-feeding sulfur dioxide for dechlorination.

24. State the reasons why sodium sulfate or sodium metabisulfite might be used instead of sulfur dioxide for dechlorination.

25. List the daily routine operational checks that should be done on gas chlorination and sulfonation systems.

26. Discuss the operational effectiveness of ultraviolet disinfection.

27. Discuss the operational controls for ultraviolet disinfection.

28. Describe the factors that control the dosage of ultraviolet radiation.

29. Describe the affect on the quality of ultraviolet disinfection of the following situations:

    A. Suspended Solids in the Effluent
    B. Certain Soluble Organic and Inorganic Chemicals
    C. High Iron Content or Color in the Effluent
    D. Visible Light on Ultraviolet Treated Effluent (Photo Reactivation).

CONCEPT: MAINTENANCE

30. Discuss the initial testing for leaks in a permanent piping system for chlorine prior to start-up and during operation.

31. State why permanent piping should be free of chlorine before any welding is done.

32. Discuss the importance of removing oil and grease residues from all piping equipment, and the procedures used for cleaning this equipment.

33. State why it is important to periodically replace the temporary flexible copper tubing connections from chlorine containers to the permanent piping.

34. Describe the cause of discoloration or corrosion on steel permanent piping systems for chlorine.

35. Describe the physical methods of cleaning ultraviolet quartz lamps, including equipment and chemicals used.

36. Discuss the reason for ultraviolet lamp replacement, and state the expected life of ultraviolet lamps.

37. Describe the deterioration of the quartz sleeves used in ultra-violet systems, and state the expected life of the quartz sleeves.

MODULE C: MONITORING AND TROUBLESHOOTING

CONCEPT: MONITORING

38. Discuss how the effectiveness of disinfection is determined.

39. List the three recommended test methods used for determining total chlorine residual, and the maximum allowable time prior to analysis.

40. State the test basis of the effectiveness of dechlorination.

41. List the colors of total coliform and fecal coliform colonies as found when using the membrane filter technique.

42. State the acceptable range for fecal coliform colony counts when using the membrane filter technique, and discuss the use of colony counts in the determinations of fecal coliform density.

CONCEPT: TROUBLESHOOTING

43. Discuss the problems with improperly sized rotameters.

44. List materials that can cause an increase in chlorine demand.

45. Discuss the causes and corrections for a leaking cylinder valve.

46. List chemical solutions used to neutralize chlorine leaks.

47. State the possible causes and corrections for the following problems with a gas chlorinator:

    A. Chlorinator Will Not Feed Chlorine (Or Low Feed Rates)
    B. Wide Variations in Chlorine Residual
    C. Coliform Count Fails To Meet Permit Requirements

48. List and discuss the causes of poor disinfection results from ultraviolet systems.

MODULE D: SAFETY AND CALCULATIONS

CONCEPT: SAFETY

49. Discuss the types of respiratory protection that should be used when working with chlorine or sulfur dioxide.

50. Discuss the types of emergency leak repair kits for chlorine, and when repair kits are required.

51. Discuss the use of protective clothing when working on large gas (chlorine or sulfur dioxide) leaks.

52. Describe the storage location for safety equipment used when working with chlorine or sulfur dioxide.

53. What are the safety concerns when using ultraviolet radiation for disinfection.

54. Discuss why soapy water is not used for leak detection for chlorine gas or sulfur dioxide gas.

CONCEPT: CALCULATION

55. Given data, calculate a geometric mean of fecal coliform results.

56. Given data, calculate a fecal coliform density from the colony counts on membrane filters.

57. Given data, calculate approximate sample size to be applied to a membrane filter using an estimated coliform density.

58. Given data, calculate the detention time in a chlorine contact tank.

59. Given data, calculate the amount of hypochlorite solution needed.

60. Given data, calculate the sulfur dioxide dosage required to neutralize the chlorine residual.

61. Given data, calculate the chlorine demand of a wastewater plant.

RESOURCES

1. **CL(2) - CHLORINE**. (1991). PPG Industries, Inc., One PPG Place, Pittsburgh, PA 15272 or Chicago Sales Office, 3030 Warrenville Road, Suite 615, Lisle, IL 60532. Phone (708) 505-1250 or (800) 243-6774.

2. **CONTROLLING WASTEWATER TREATMENT PROCESSES**. (1984). Cortinovis, Dan. Ridgeline Press, 1136 Orchard Road, Lafayette, CA 94549.

3. **MUNICIPAL WASTEWATER DISINFECTION**. EPA/625/1-86/021 (1986). U.S.Environmental Protection Agency, Office of Water Program Operation, Washington, DC 20090.

4. **OPERATION OF MUNICIPAL WASTEWATER TREATMENT PLANTS**. Manual of Practice No.11(MOP 11), 2nd Addition (1990), Volumes I, II, and III. Water Environment Federation (Old WPCF), 601 Wythe Street, Alexandria, VA 22314-1994. Phone (800) 666-0206. (MOP 11, 1976 can still be used as a reference.)

5. **OPERATION OF WASTEWATER TREATMENT PLANTS**. 3rd Edition (1990), Volumes 1 and 2, Kenneth D. Kerri, California State University, 6000 J Street, Sacramento, CA 95819-6025. Phone (916) 278-6142.

6. **STANDARD METHODS FOR THE EXAMINATION OF WATER AND WASTEWATER**. 17th Edition (1989), 18th Edition (1992). Joint Publication of: American Public Health Association; American Water Works Association;and, Water Environment Federation (Old WPCF). Publication Office: American Public Health Association, 1015 Fifteenth Street NW, Washington, DC 20005.

7. **ULTRAVIOLET DISINFECTION TECHNOLOGY ASSESSMENT**. EPA 832-R-92-004 (1992). U.S.Environmental Protection Agency, Office of Water Program Operation, Washington, DC 20090.

8. **WISCONSIN ADMINISTRATIVE CODE, NR 110, SEWERAGE SYSTEMS**. Wisconsin Department of Natural Resources, Attn: Ken Cramer, P.O. Box 7921, Madison, WI 53707.

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